



Project Summary

Development of a Linear Compressor for Air Conditioners and Heat Pumps

Warren D. Waldron

The objective of this work was to design, build, test, and deliver to the Environmental Protection Agency (EPA) a linear compressor for operation in a 3.0-ton (10.5 kW) residential air-conditioning and heat pumping system. The compressor design evolved from a linear resonant piston compressor (RPC) developed previously by Mechanical Technology Inc. (MTI) for air-conditioning applications. During the design effort, the RPC was modified to extend its range into the heating mode, and a voltage controller was developed that could sense the proximity of the compressor plunger to the top dead center (TDC) and bottom dead center (BDC) stops and limit the plunger stroke. Following the design and construction of the RPC, a test program was conducted. This effort was successful, except for several minor difficulties, including a failure in the epoxy bond of the compressor plunger. The causes of the problems encountered are well understood, and the modifications required to correct them are known and simple to implement. The test results proved the performance advantage of the RPC in terms of a high Seasonal Energy Efficiency Rating (SEER) potential and also demonstrated that the compressor can be controlled in a stable manner using low cost, commercially available motor control devices.

This Project Summary was developed by EPA's National Risk Management Research Laboratory's Air Pollution Prevention and Control Division, Research Triangle Park, NC, to announce key findings of the research project

that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Overview

This report describes the work performed to design, build, test, and deliver a linear compressor intended for operation in a 3.0-ton (10.5 kW) (nominal) residential air-conditioning and heat pumping system.

The primary advantage of a linear-motor-driven compressor for a high-efficiency air-conditioning/heat pumping application is that it is easily modulated; i.e., it has variable capacity capability in that the displacement can be varied by varying the compressor stroke. Conventional rotating compressors can be modulated by varying the compressor speed by means of a variable frequency power source. The linear compressor, on the other hand, achieves modulation by means of variable voltage. Variable voltage power devices are considerably less expensive than variable frequency devices, thus the potential advantage of the linear compressor in modulated (variable capacity) applications.

The subject compressor design evolved from a linear resonant piston compressor (RPC) developed previously by MTI for air-conditioning applications from 1987 through 1991. This compressor design was modified under the EPA program to extend its range into the heating mode. A voltage controller was developed that can sense the proximity of the compressor plunger to the top dead center (TDC) and bottom dead center (BDC) stops and limit the plunger stroke. This controller uses a manually operated potentiometer to simu-

late the input normally derived from a normal system temperature controller to modulate the compressor output (mass flow rate).

A conventional, commercially available, high-efficiency heat pump compressor previously tested by its manufacturer (Bristol Compressor Co.) was used as a qualification test system for the linear RPC. The results showed that the RPC had essentially the same performance as the conventional compressor under normally encountered cooling conditions in the U.S. Combined with the RPC's excellent modulation performance, these results will lead to very high Seasonal Energy Efficiency Ratings (SEERs) because the modulation capability of the RPC eliminates the need

for excessive cycling at moderate outdoor temperatures.

The test program was prematurely terminated due to structural failure of the epoxy bond that secures the motor plunger permanent magnets to the plunger frame. This failure was due to the use of a plunger built for another program that was not a hydrochlorofluorocarbon (HCFC) refrigerant application. It was later determined that the epoxy used was incompatible with the HCFC-22 refrigerant.

The test program was successful, except for several minor development issues. Unfortunately, the plunger epoxy bond failure prevented conclusion of the test program and a complete demonstration of the efficiency and modulation ad-

vantages of the RPC. The problem causes are well understood, and the needed modifications known and simple to implement. Such developmental issues are normal in prototype projects and in no way indicate that the RPC is not a viable device for a high-efficiency residential air-conditioning and heat pumping system. On the contrary, the data included in the report prove its performance advantage in terms of a very high SEER potential. Further, the test program demonstrated that the RPC can be controlled in a stable manner using low-cost, commercially available motor control devices.

Warren D. Waldron is with Mechanical Technology Inc., Latham, NY 12110.

James J. Jetter is the EPA Project Officer (see below).

The complete report, entitled "Development of a Linear Compressor for Air Conditioners and Heat Pumps," (Order No. PB97-189 690; Cost: \$21.50, subject to change) will be available only from:

*National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650*

The EPA Project Officer can be contacted at:

*Air Pollution Prevention and Control Division
National Risk Management Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711*

United States
Environmental Protection Agency
Center for Environmental Research Information
Cincinnati, OH 45268

Official Business
Penalty for Private Use \$300

EPA/600/SR-97/070

BULK RATE
POSTAGE & FEES PAID
EPA
PERMIT No. G-35